THE EFFECTS OF FOOTWEAR HEEL-TO-TOE HEIGHT ON LOWER EXTREMITY JOINT KINEMATICS

Presenters: Amanda Aussems, Danielle Kawryga, Allison Macari, Angelica Romeu
Faculty Sponsor: Rumit Singh Kakar, PT, PhD

Background

Decreased ankle range of motion (ROM) is a common result of many lower extremity conditions, including plantar fasciitis and achilles tendinopathy[1]. Footwear modifications and foot orthotic fabrication are widely used in clinical practice to treat these injuries, yet the degree of effect when changing heel-to-toe heights, or "heel drop", in athletic shoes in lower extremity (LE) joint ROM is unclear and has not been widely studied[1-2]. Thus, there is a void in the current literature regarding the effects of heel-to-toe height in athletic footwear while walking. We hypothesize athletic footwear with increased heel drop will allow for more available range of dorsiflexion during gait, as shoes with increased height will put the foot in a more plantarflexed position at baseline. We also expect to see a decrease in step-length and an increase in cadence, as the change in heel height will shift the center of mass anteriorly. Despite full LE involvement, we do believe the most changes will occur at the ankle joint.

Purpose

The purpose of this research study is to better understand how varying heel-to-toe height in athletic footwear will affect step length, cadence, and available joint range of motion during a typical gait cycle.

Methods

One healthy, female individual (age: 23 years, height: 175.26cm, mass: 74.84kg) served as both subject and control. Standard running shoes (size 10-10.5B) with varying heel-to-toe heights (Altra: 0mm, Hoka: 5mm, Brooks: 12mm) served as independent variables. Sixteen bilateral markers were placed on various lower extremity anatomical landmarks to capture osteokinematic motion through an 8 camera- 3 dimensional motion analysis system. The subject walked a 10 meter length onto two force plates at a self-selected pace. The subject's step cadence, step length, and hip, knee, and ankle ROM were analyzed in the sagittal plane while walking in the three different shoes.

Results

The three trials for each sneaker were averaged together and compared. While step length and cadence remained relatively similar (Ultra: 1.45 meters, 1.75 steps/second; Hoka: 1.48 meters, 1.63 steps/ second; Brooks: 1.44 meters, 1.70 steps/second), there were osteokinematic differences noted when wearing the Brooks when compared to the Hokas and the Altras. In the Brooks, the ankle was in a more dorsiflexed position and the knee was in a more extended position at initial contact, and this trend continued throughout midstance (max knee flexion: 44.1° ; max ankle dorsiflexion: 15.8°). During late stance, the subject remained in more knee extension and achieved a larger hip extension angle (knee flexion: 0.3°; hip extension: 9.7°) which allowed for a prolonged stance phase.

Discussion and Conclusion

These results demonstrate that athletic footwear with a higher heel drop increases the available range of motion into dorsiflexion by putting the ankle in a more plantarflexed position to start. These changes at the ankle produce osteokinematic changes at the knee and hip during various points of the gait cycle due to the kinetic chain. This information is clinically applicable for individuals with limited dorsiflexion range of motion, who may benefit from the changes produced by wearing footwear with a larger heel drop. Reducing these functional limitations at the ankle may provide a secondary benefit of decreasing the potential for injuries up the kinetic chain.

Citations

1. Menz, H.B., Pazit, L., Tan, J.M., Auhl, M., Roddy, E., Munteanu, S.E. (2014). Rocker-sole footwear versus prefabricated foot orthoses for the treatment of pain associated with first metatarsophalangeal joint osteoarthritis: study protocol for a randomized trial. *BMC Musculoskelet Disord*, 15, 86. Retrieved from https://doi.org/10.1186/1471-2474-15-86.
2. Hutchins, S., Bowker, P., Geary, N., Richards, J. (2009). The biomechanics and clinical efficacy of footwear adapted with rocker profiles: Evidence in the literature. *The Foot*, 19, 165-170. doi:10.1016/j.foot.2009.01.001.